Presenting the Case for NASA Space Science

Presentation to the HEPAP

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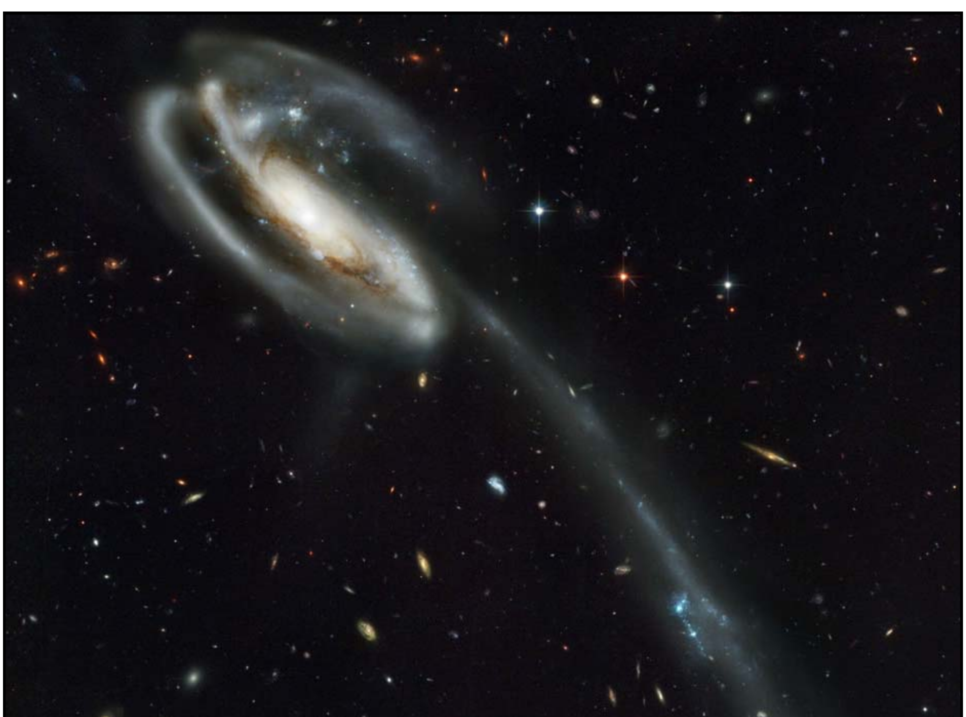


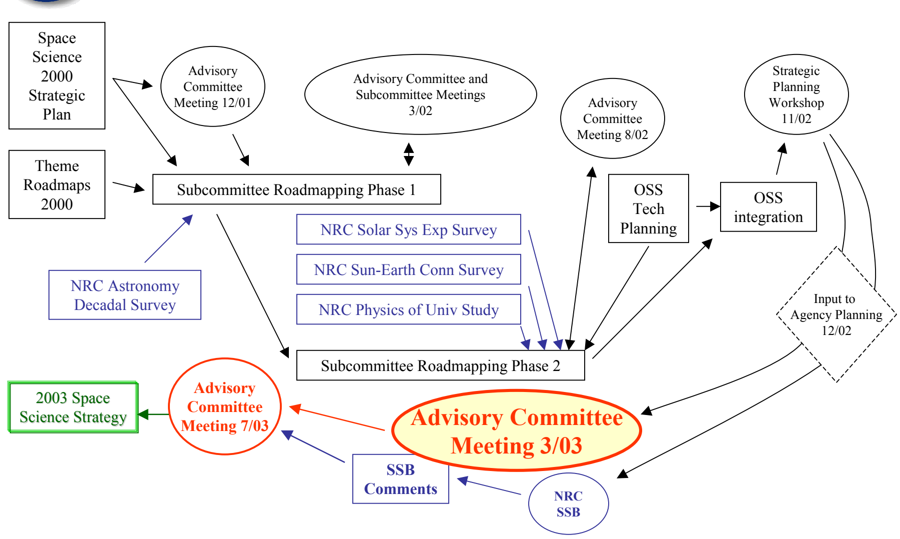
Presenting the Case for Space Science

- Formulating the Plan
- Presenting the Case
  - Structure and Evolution of the Universe
- Outreach to the Stakeholders
- Measuring Outcomes

Space Science Planning

- Planning process begins with science community
  - Decadal Surveys (NAS/NRC)
  - Space Studies Board (SSB)
  - Space Science Advisory Committee (SScAC)
  - Subcommittee roadmapping teams for each Theme
- Roadmaps include objectives and research focus areas
  - Look out 10 years
  - Feed into Agency planning
- Final Enterprise Strategy reflects Agency-level Objectives

2003 Strategic Planning Process



Code S Strategy Features

- Focus on Agency Objectives and how we achieve them
  - Less on past achievements
- Follows GPRA strategic plan requirements
  - Goals
  - Objectives
  - Achieving them
  - Relationship to performance plan
  - External factors
  - Evaluation
- Starts with NASA Mission Areas and Strategic Goals
  - Shows how Space Science Objectives support NASA Goals
  - Elaborate on how we achieve Objectives
    - Flight programs, technology development, research and analysis, education and public outreach
    - Partnerships within and outside the Agency

Code S Strategy Features

- Firmly anchor flight program in strategic science goals and objectives and maintain a strong research base
- Aggregate consecutive missions that address a cluster of science goals into "mission lines"
  - Advantages of science-based mission lines include better political and public advocacy via an integrated scientific "package" and improved continuity in budget and technology planning
  - Within a line, fly successive missions as science priorities dictate and available resources and technological capability permit

Code S Strategy Features

- Many purposes for the Space Science Enterprise Strategic Plan
  - OMB and Congress: tool for program and budget advocacy
  - Science Community: documents consensus on goals and priorities
  - NASA Agency-level: for NASA Strategic Plan (and GPRA)
  - The Public: handbook on what Space Science is going to do and why
  - NASA enterprises: information for inter-enterprise collaboration
  - NASA OSS: reference for programmatic decision-making

New Agency Mission and Vision

To improve life here,

To extend life to there,

To find life beyond

To understand and protect our home planet

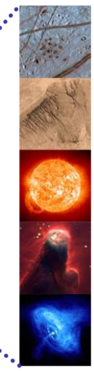
To explore the Universe and search for life

To inspire the next generation of explorers

. . . as only NASA can

2003 Space Science Strategy Outline

- Introduction
  - Highlights
- NASA Vision and Mission
- Role of Space Science
  - Objectives
  - Principles and Policies
- Achieving Space Science Objectives
  - Program Elements
  - Science Themes
  - Technology Requirements
  - Partnerships
- Resource Requirements
- Relationship to Agency Performance Plan
- External Factors
- Evaluation



Solar System Exploration

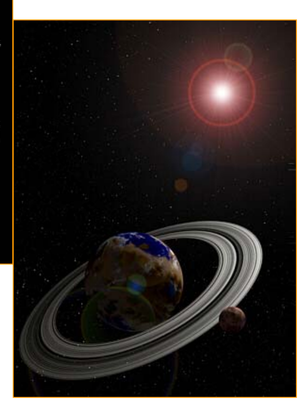
Mars Exploration

Sun-Earth Connection

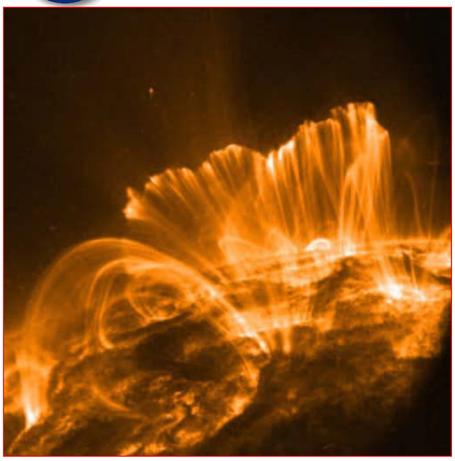
Astronomical Search for Origins

Structure & Evolution of the Universe

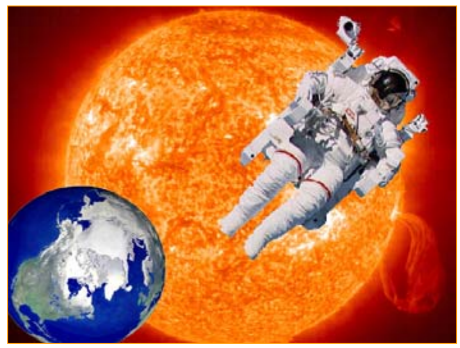
Detection of Extra-Solar Planets



Living With a Star



Understanding the Sun-
Earth system and how it
directly affects life and
society on Earth



Mars Exploration Plan: “Follow the Water”

When • Where • Form • Amount

Structure & Evolution of the Universe

Objective	**Research Focus Areas**
Discover what powered the Big Bang and the nature of the mysterious dark energy that is pulling the Universe apart.	Search for gravitational waves from the earliest moments of the Big Bang. Determine the size, shape, and matter-energy content of the Universe. Measure the cosmic evolution of the dark energy, which controls the destiny of the Universe.
Learn what happens to space, time, and matter at the edge of a black hole.	Determine how black holes are formed, where they are, and how they evolve. Test Einstein's theory of gravity and map space-time near event horizons of black holes. Observe stars and other material plunging into black holes.
Understand the development of structure and the cycles of matter and energy in the evolving Universe.	Determine how, where, and when the chemical elements were made, and trace the flows of energy and magnetic fields that exchange them between stars, dust, and gas. Explore the behavior of matter in extreme astrophysical environments, including disks, cosmic jets, and the sources of gamma-ray bursts and cosmic rays. Discover how the interplay of baryons, dark matter, and gravity shapes galaxies and systems of galaxies.

BEYOND EINSTEIN

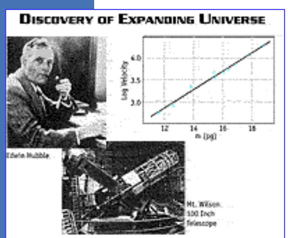
Einstein's Predictions

Three startling predictions of Einstein's relativity:

- **The expansion of the Universe (from a big bang)**
- **Black holes**
- **Dark energy acting against the pull of gravity**

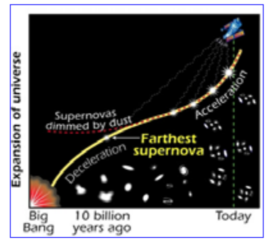
Observations confirm these predictions . . .

. . . the last only four years ago



Hubble discovered the expanding Universe in 1929

Black holes found in our Galaxy and at the center of quasars over the past three decades



Evidence for an accelerating Universe was observed in 1998

BEYOND EINSTEIN

Completing Einstein's Legacy

Einstein's legacy is incomplete, his theory fails to explain the underlying physics of the very phenomena his work predicted

BIG BANG

What powered the Big Bang?

BLACK HOLES

What happens at the edge of a Black Hole?

DARK ENERGY

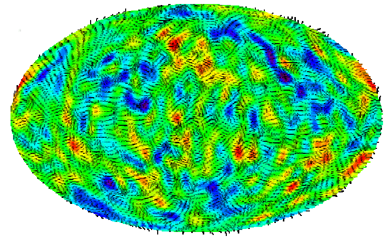
What is the mysterious Dark Energy pulling the Universe apart?

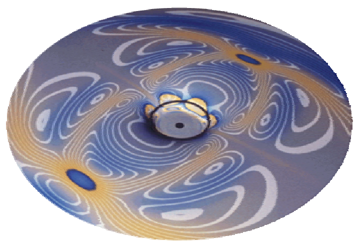
Beyond Einstein will employ a series of missions linked by powerful new technologies and common science goals to answer these questions …

… and launch the revolution of the 21st century!

What Powered the Big Bang?

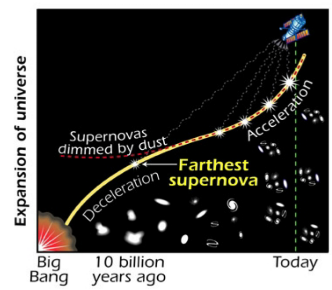
Gravitational waves leave a distinctive imprint on polarization pattern of CMB



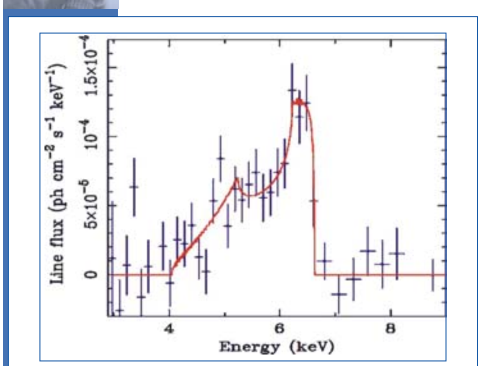


Gravitational waves from inflation and phase transitions may be detected directly

Vacuum energy powered inflation-some form of it may be the “dark energy”

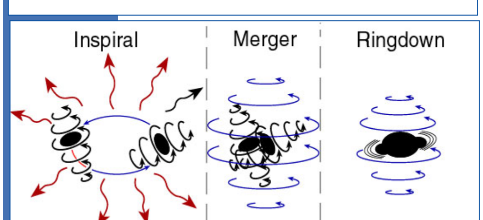


What Happens at the Edge of a Black Hole?



X-Ray Spectroscopy

- **Japan-US ASCA satellite discovered iron lines near the event horizon of a black hole**
- **Line exhibits a strong redshift and provides a unique probe of the inner regions of black holes**

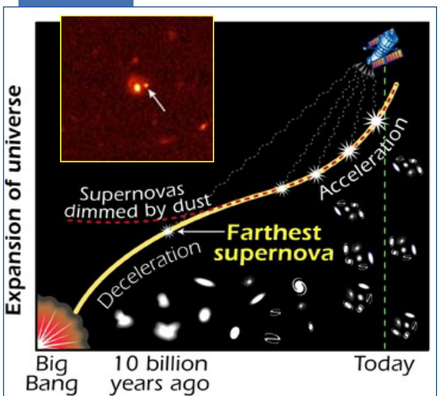


Gravitational Radiation

- **Black hole binaries produce gravitational waves in all phases of their evolution**
- **Test of GR in all three phases**

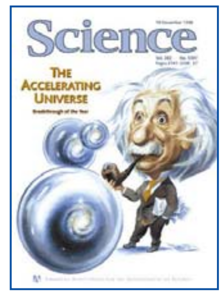
What is the Dark Energy?

Einstein introduced the Cosmological Constant to explain what was then thought to be a static Universe, "*my biggest mistake . . .* "



A surprising recent discovery has been the discovery that the expansion of the Universe is accelerating.

Implies the existence of *dark energy* that makes up 65% of the Universe



Dark Energy maybe related to Einstein's Cosmological Constant; its nature is a mystery.

Solving this mystery may revolutionize physics . . .

Realizing Science Beyond Einstein

Three inter-linked elements that work together:

1. **<u>Einstein Great Observatories</u> providing breakthrough increases in capabilities to address all Beyond Einstein science:**
   - **LISA: Gravitational waves from merging black holes and the early Universe**
   - **Constellation-X: Spectroscopy close to the event horizon of black holes and place constraints on dark side of the Universe**
2. **<u>Einstein Probes</u> to address focused science objectives:**
   - **Determine the nature of the Dark Energy**
   - **Search for the signature of inflation in the microwave background**
   - **Take a census of Black Holes of all sizes in the local Universe**
3. **<u>A technology program, theoretical studies and an education program</u> to inspire future generations of scientists and engineers towards the vision:**
   - **Directly detect the gravitational waves emitted during the Big Bang**
   - **Image and resolve the event horizon of a Black Hole**

BEYOND EINSTEIN

Beyond Einstein Program

Science and Technology Precursors

- MAP
- LIGO
- Hubble
- Chandra
- GLAST

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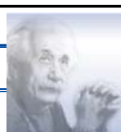


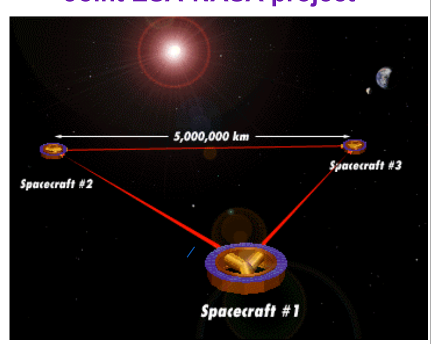
BEYOND EINSTEIN

Laser Interferometer Space Antenna (LISA)

Joint ESA-NASA project

LISA uses a laser based Michelson interferometer to monitor the separation between proof masses in separate spacecraft

- **Three spacecraft separated by 5 million km**
- **Each spacecraft includes two freely falling test masses with drag free operation**
- **Distance <u>changes</u> measured with precision of 4 ppm RMS over 100 seconds**



Flight demonstration of disturbance reduction system ST-7 on ESA SMART-2 mission in 2006

micro-newton thrusters

LISA, the first space-based gravitational wave antenna, was given strong endorsement by US National Academy of Sciences McKee-Taylor and Turner Committee Reports

Constellation-X

Use X-ray spectroscopy to observe

- Black holes:
  - Probe close to the event horizon
  - Evolution with redshift
- Dark side of the Universe:
  - Clusters of galaxies and large-scale structure
- Production and recycling of the elements:
  - Supernovae and interstellar medium

- 25-100 times sensitivity gain for high resolution spectroscopy in the 0.25 to 10 keV band
- Four satellites at L2 operating as one with advanced X-ray spectrometers

Enable high resolution spectroscopy of faint X-ray sources

**Constellation-X given strong endorsement by
US National Academy of Sciences
McKee-Taylor and Turner Committee Reports**

Einstein Probes

Three focused missions, each designed to address a single high priority science question

- Priority and science topic determined via NASA strategic planning process, using National Academy recommendations
  - Dark Energy Probe
  - Inflation Probe
  - Black Hole Finder Probe

- Competed Principle Investigator missions
  - Implementation approach determined by peer review
  - Launched every 3-4 years
  - $350-500M class missions

BEYOND EINSTEIN

National Research Council Endorsements

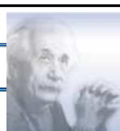
Astronomy & Astrophysics in the New Millennium
2001 Decadal Survey (McKee-Taylor)

Major Initiatives:

1. NGST
2. Constellation-X Observatory
3. Terrestrial Planet Finder
4. Single Aperture Far Infrared Observatory

Moderate Initiatives

1. Gamma-ray Large Area Space Telescope
2. Laser Interferometer Space Antenna
3. Solar Dynamics Observatory
4. Energetic X-Ray Imaging Survey Telescope
5. Advanced Radio Interferometry Between Space & Earth



BEYOND EINSTEIN

National Research Council Endorsements

Connecting Quarks with the Cosmos
2002 (Turner) Not a priority list.

- Measure the polarization of the CMB
- Determine the properties of dark energy
- Use space to probe basic laws of physics (Con-X, LISA)
- (Highest energy cosmic rays)
- (High-energy-density physics)
- (Interagency Initiative)
- (Neutrino masses)

Beyond Einstein Timeline

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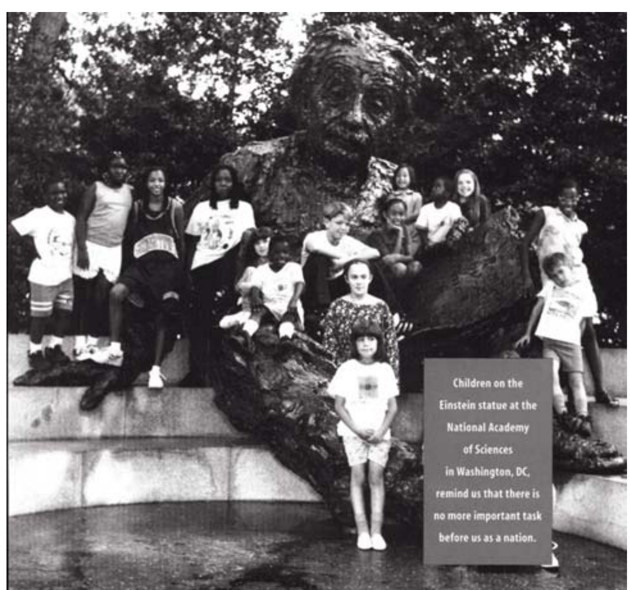
Education and Public Outreach

Big Bang and black holes capture the imagination and can be used to teach physical science at all levels

Beyond Einstein will address the national education priority by inspiring future generations of scientists and engineers, as only NASA can . . .



BEYOND EINSTEIN

The 21st Century

How did the Universe begin? Does time have beginning & an end? Does space have edges? The questions are as old as human curiosity. But the answers have always seemed beyond the reach of science. . .

until now!

Education and Public Outreach Research Focus Areas

Improve student proficiency in science, technology, engineering and mathematics using educational programs, products, and services based on NASA's unique missions, discoveries, and innovations.
Motivate K-16+ students from diverse communities to pursue science and math courses, and ultimately college degrees in science, technology, engineering, and mathematics.
Improve science, technology, engineering, and mathematics instruction with unique teaching tools and experiences that are compelling to teachers and students.
Improve higher education capacity to provide for NASA's and the Nation's future science and technology workforce requirements.
Improve the capacity of science centers, museums, and other institutions through the development of partnerships, to translate and deliver engaging NASA content.
Engage the public in NASA missions and discoveries through avenues in public programs, community outreach, mass media, and the internet

Extent of FY 2002 OSS E/PO Program

- 330 E/PO activities and 70 new products
- More than 3,600 discrete E/PO events
- Over 100 OSS Missions and Programs
- Over 1,000 OSS-affiliated scientists, technologists, and support staff
- Over 500 institutional partners, including: 150 science centers, museums, planetaria; 20 pre-college educational organizations, school districts and boards; 175 science institutions and organizations, colleges and universities (including 29 minority institutions).

Estimated participants:

- Over 350,000 direct participants in workshops, community/school visits, and other interactive special events.
- Over 1.7 million visitors for museum exhibitions, planetarium shows, public lectures, and special events.
- Over 7 million Internet participants for web casts, web chats, and other web events.
- Accessible to 200 million through conference exhibits, radio and television broadcasts, newspaper columns, and other forms of public media.

Public Affairs

- Public Affairs (PA) is not Education and Public Outreach (E/PO)
- Communicating results to the public is important
  - Included in NASA's Charter (Space Act of 1958)
- Communicating results effectively requires planning
  - It does not happen spontaneously
  - It requires professionals
- OSS uses a multi-layer strategy for PA
  - Center and University press releases
  - Headquarters press releases
  - Space Science Updates

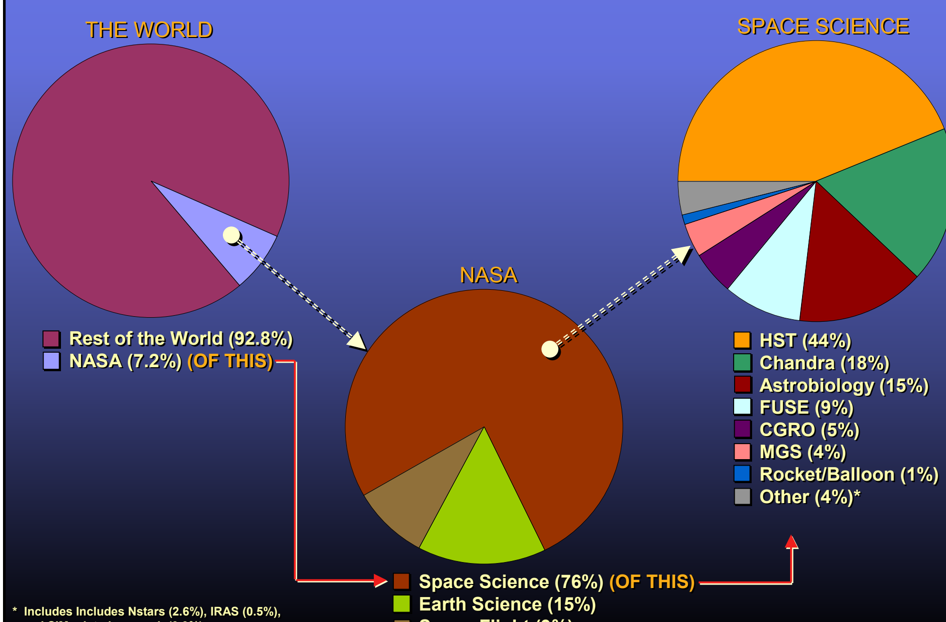
Space Science Updates

- Funded activities at GSFC, JPL, STScI, SAO/CXC
- Identification of candidate science results
  - Accepted by peer reviewed journal
  - Not yet publicly available
  - Interesting to the educated layperson
  - Approved by Editorial Board
- Thorough preparation
  - Identification of presenters and commentators
  - Multiple telecons and rehearsals
  - Development of graphics, animations, analogies, background
  - Personal contact with science reporters

Some Good Press

2002 Science News Metrics

Contributions to World Discoveries and Technological Achievements



* Includes Includes Nstars (2.6%), IRAS (0.5%), and SIM related research (0.9%)

OSS Budget History